An Interactive Low-Cost Smart Assistant System: Information Kiosk as Plug & Play Device

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Abstract— **The demand for a self-service device that can relay the information of an organization while maintaining privacy is quite crucial in today's world. The introduction of kiosks in such states resolves this issue but the prevailing kiosk manufacturing companies don't provide a plug & play system for kiosks. In order to nullify these issues, the design of an information kiosk as a plug & play system has been described in this paper. This kiosk can provide real-time information to the users removing the necessity of any sort of human assistance. Unlike the existing kiosks, this is a plug & play device, which makes it easier to install any specification or modification required as per the organization's requirement. It also stands out from the existing ones through the use of image processing and computer vision making it more interactive as well as user friendly. The system also possesses the capability of processing a vast amount of data. These data are collected through sensors and other means as well as conveying with high accuracy and privacy. Furthermore, the system is low-cost in comparison with the available kiosks in the market.**

I. INTRODUCTION

The 21st century is known for the information revolution where breathtaking inventions have completely changed the way we live. Implementation of information technology has vastly affected every sphere of human life including education and communication. However, real-time information collection is still considered an immense problem worldwide. The growing population has made the situation worse as accessing data has become more challenging. A report by the United Nations declares that by 2030, the global population is likely to reach 8.5 billion [1]. Growing populations are demanding some feasible solutions to access data within the shortest possible time. As a result, scientists have developed many cutting-edge technologies to satisfy their needs. Among these solutions, interactive kiosks can become a standout in terms of feasibility and accessibility.

An interactive kiosk is mainly an electronic device that is equipped with modern hardware and software to provide features like navigation, entertainment, and information; reducing the need for human assistance. Since its invention in 1977, the kiosk has been widely used worldwide mostly for commercial and navigation purposes. Public areas where people require information within a short span, kiosks are playing a huge role. Worldwide researchers working seamlessly within this field, creating numerous face detection algorithms, on-screen navigation systems, and the user database. There are a lot of works and projects done regarding kiosks and features that can be added to it; by researchers from all around the world at different times. As shown by D. Suputra and K. Amin, it is possible to detect humans using a webcam in different lighting conditions. In their project, they were able to perform live detection of the human using both webcam and CCTV with the use of MATLAB [2]. In our project, a similar human detection was performed using a different approach. H. Kaur and S. Malhotra briefly described the potential of a kiosk to reduce hassle in a library [3]. They recommend kiosk as an alternative to the information desk as it can provide information facility 24/7. M. Viitanen, A. Koivula, J. Vanne, and T. Hämäläinen showed a low-cost system built with Raspberry Pi 2, that was used for remote surveillance [4]. In our system, Raspberry Pi 4B+ was used with a much broader facility. S. Kulkarni, A. Harale, and A. Thakuret developed a system where Raspberry Pi and Webcam were used to detect the drowsiness of drivers that can sound an alarm to wake up the driver as well as SMS to be sent to an emergency contact [5]. Our system was built in such a way that depending upon the detection of a person's facial emotion, the notification section from the dataset will be offered accordingly. R. Rahmat, T. Saputra, A. Hizriadi, T. Lini, and M. Nasution showed a performance test carrying out a parallel image processing using Open MPI on Raspberry Pi [6]. In another work, V. Bhanse and M. Jaybhaye had achieved higher accuracy in face detection and image processing using OpenCV and Raspberry Pi [7]. In our work, similar accuracy was achieved, and OpenCV was also used in building the system. A. Shi, X. Wang, Y. Chen and J. Yu developed a system that can be used in the university campus to provide public information using the identity authentication through ID cards and share information or data resource [8]. Our system can perform this authentication through organizational ID cards and share data through the system upon authentication of the user. Also, our system is made user-friendly to be used for public information sharing as well. This system can be implemented for the e-health system of developing countries [9]. Sushma and S. Ambareesh showed an indoor navigation system based on QR code scanning [10]. Our system has the facility to provide navigation of an indoor environment of office or campus and show the pinpoint destination of a certain office or room. The system contains maps of several floors and buildings of an organization; based on the user's search, the destination will be shown with a brief detail on the map.

In this paper, the development of an information kiosk has been discussed which was created with the aim to simplify the human lifestyle and provide faster access to data. The kiosk can provide reliable and fast information to the user of an organization. The novelty of the project lies in the inclusion of different state-of-the-art technologies, unlike the existing kiosk model which provides limited features depending on their users. Among these features, image processing using machine learning is the most notable one. The kiosk uses this image processing feature for human detection, which in the long run can effectively reduce the time consumption of the system. Using this device, any organization can speed up its operation without the help of any personnel, as the control is quick and user-friendly. In addition to that, it can solve the issues where an organization is not comfortable with sharing its information online like office map and employee information; by providing the flexibility of controlling their data. While using this feature, they can guide their user with precise information which is not available on the internet. The results shown in this paper are based on its operation within a university; where it can provide the required information to the users instantly. Currently, the device has an interactive application which can provide services like campus navigation, department wise faculty information, student portal login using face recognition and RFID card identification, data processing through different sensors, etc. As this kiosk is a self-service interactive device, the users do not require any kind of external help while operating.

II. METHODOLOGY

In the buildup of this proposed system, numerous sources of works by researchers in different sectors were used as the inspiration and for the development of the project. Features like image recognition, machine learning, data management, controlling multiple sensors at the same time, etc. are merged to make the system more reliable, efficient, and interactive for the users.

A. Working principles of the proposed system

The block diagram of the developed information kiosk has been shown in Fig. 1. In order to minimize power consumption, the device was designed in a way that it would stay idle with the display screen going dark when no user is nearby. The Raspberry Pi works as the main operating system which controls various processing and navigates between different devices. As shown in [11], [12] and [13], Raspberry Pi can be used efficiently to perform facial recognition and other activities. In our project, the camera connected to the kiosk constantly scans the area to detect any human movement. The device has the feature to perform real-time image processing and the ability to differentiate between humans and other objects. Once the captured data from the captured video images match the dataset, it can recognize humans. After detecting any human movement, the relay is triggered to turn on the device screen and it welcomes the user through the display screen with the home screen appearing to be visible on the screen along with music or welcoming sound from the sound system. The system also enables the users to log into their organizational accounts as well for carrying out their works through their accounts along with browsing the internet.

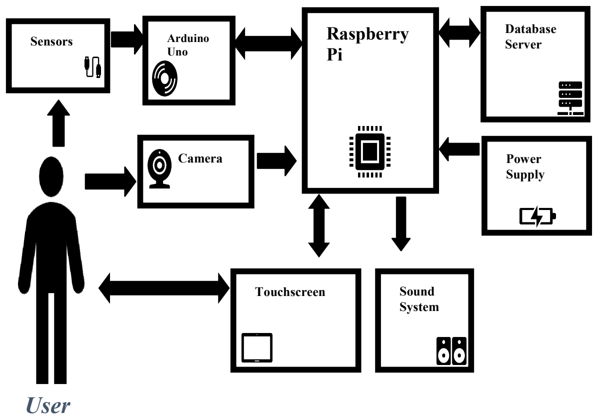

Fig. 1. System Block Diagram

In this case, students or authorized people can log in to their organizational user account automatically by the facial recognition by the system or by using their RFID card tag on the sensor pad. This enables the person to keep the privacy of their works through their account. While using the device, the users can get their desirable data at a fast speed as the Raspberry Pi fetches that data from an external database server. This enables us to secure the data of the system even more. On the other hand, the power consumption of the whole system is always kept at a minimum.

B. Image Processing Feature

The flowchart of the image processing feature is shown in Fig. 2. Here, Raspberry Pi works as the main processor. We were inspired by the works of Adrian Rosebroke [14] in this part of the image processing and developed this with a python framework called OpenCV, which is a machine learning library. It allows real-time computer vision features with excellent accuracy. As demonstrated in [15] and [16], OpenCV is currently used in numerous projects to run real-time image processing. Basically, in this case, the OpenCV utilizes the Single Shot Detector (SSD) framework with ResNet as the base network. The success rate of detecting humans by the system was 98.5%, gender detection was 95% successful and emotion detection was 40% successful in the system's simulation. In our project, the library uses previously gathered human datasets. The system was proven to be highly efficient in detecting human. The human detection algorithm was developed in a way that, when any human presence is in the range of the camera, the system recognizes the human through image processing whenever the detection level reaches at least 60%. The requirement of the detection algorithm was considered less to ensure consistency as the camera performance often varies due to the low lighting condition. After the detection, the system identifies the gender and emotions of the detected user. One of the hidden features of the system is by machine learning, the system would generate news and events notification based on a person's gender and current emotional state which can be determined by the captured image of the user's face. This machine learning feature is carried out with the Python framework of OpenCV.

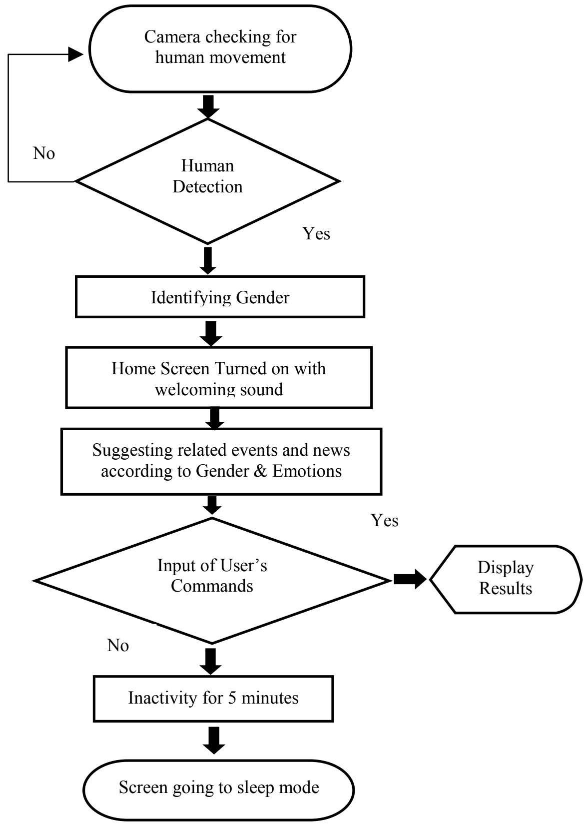

Fig. 2. Image Processing Flowchart

C. Database Development and Management

Database development and management play a crucial part in the system. The database of the system contains useful data and features; such as the organization's map in 3D view with navigation, faculty mail address, university portal login, exam seat plan, news & event notifications, organizational data, etc. The information of these features is stored in the database which is created using MySQL and can be managed by the 'xampp' software. This enables the administrator to have full control over the data. Fig. 3 shows the required database management with the admin access and the development of the database using MySQL. All the data were loaded into the database using the NodeJS. The program app of the kiosk system was developed using the Electron JS. In Fig. 4, the relation between different table within the database are shown. In which, 'TeacherProfile' is the main table that stores every data and it contains other sub-tables. The sub-tables are connected via a one-to-many relationship. The 'TeacherNoticeBody' is connected with 'TeacherNotice' which is ultimately connected to the 'TeacherProfile' table. Also, 'TeacherEducation' and 'TeacherTSF' sub-tables are connected to the 'TeacherProfile' table. In addition to that, 'GlobalNoticeBody' is the sub-table of the 'GlobalTeacherNotice' while maintaining the similarity of one-to-many relationships. All these tables are crucial in the working of the kiosk as they contain many important data which are shown to the user upon their request.

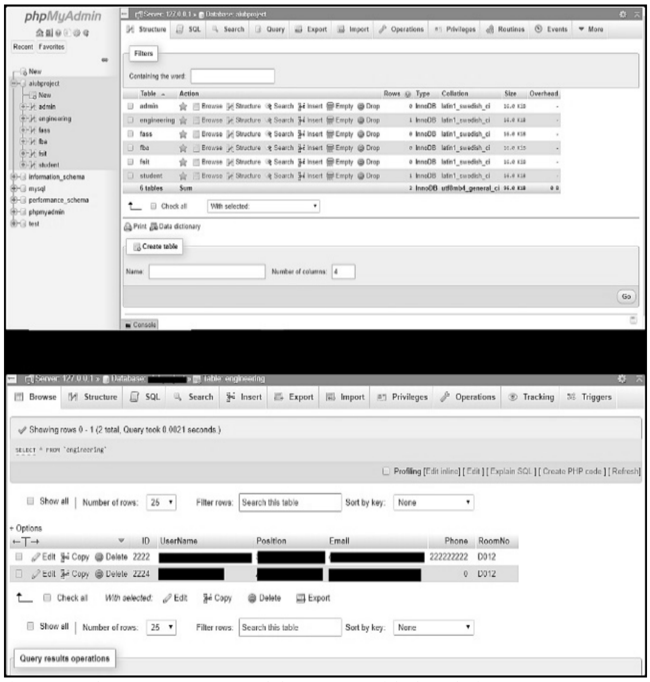

Fig. 3. Database Management of the system with the admin access

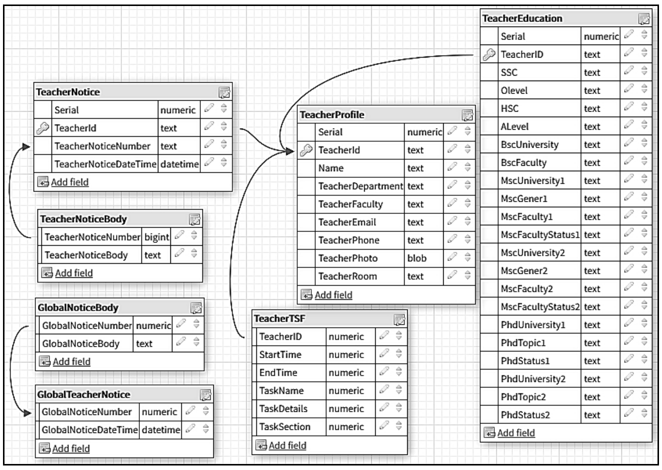

Fig. 4. Database development using MySQL

III. The Features of the System

The developed system contains some of the advanced features that proven to be interactive with users, efficient in data fetching & data management, embedded system, low-cost, and 'plug & play' system.

A. 3D Map and Email Sending Feature

One of the unique features of the developed system is the organizational map with all the necessary information inspired by the work of Mary Lou [17]. The system shows a 3D map of the organization's buildings or area to the user. The user can select any floor of the building and can get the direction of any room of the building as well. To ensure proper navigation, the device can show the current location of the user and show the direction to the desired destination inside the organization. In Fig. 5, the 3D map with necessary information and locations of different offices can be seen which was selected by the user. On the left side of Fig. 5, it shows the initial state of the map.

Whenever the user selects a particular floor, that floor comes up on the screen as shown on the right side with all the locations of different offices & rooms with personnel. A list of personnel and rooms are displayed at a side of the screen as well. The map also enables the user to get the information of any faculty member (from the perspective of a university); such as email address, designation, availability in the office, contact number, class schedule, etc.

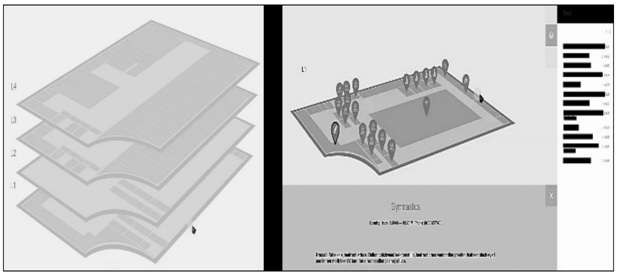

Fig. 5. Sample 3D map with necessary information

The details of the desired personnel along with how to get to that destination can be found as shown in the picture on the right side of Fig. 5 as well. The system, in this case, would allow users to send emails to employees, faculty members, or students of that particular university as shown in Fig. 6. Selecting a particular person's name from the 3D map shows his/her details. Clicking upon the email address of the person pops-up a new window to send an email from the user as shown in Fig. 7. This takes directly to the email account of the user and enables the user to create and send an email to the desired personnel.

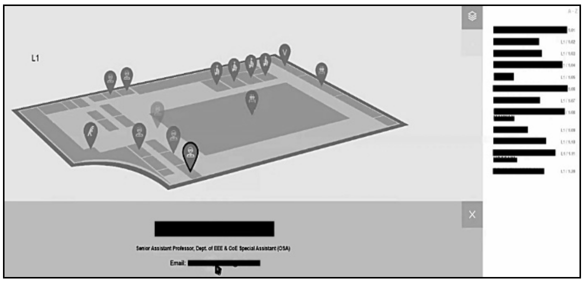

Fig. 6. 3D map of a floor with details of selected personnel

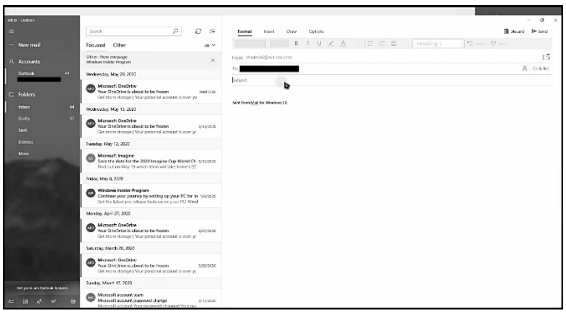

Fig. 7. Email sending feature of the system

B. 3D Seat Plan Feature

The same technique which was used to develop the 3D map of the organizational building was also used to develop a 3D view and alignment of seat-plans for the students as shown in Fig. 8. This 3D seat plan feature can help students to identify their allocated seats in their exams or class. Providing the necessary data, the 3D seat plan feature can show the allocated seat of a particular user by marking it out of the other seats after identifying that user with the login information of the user's account given on the kiosk.

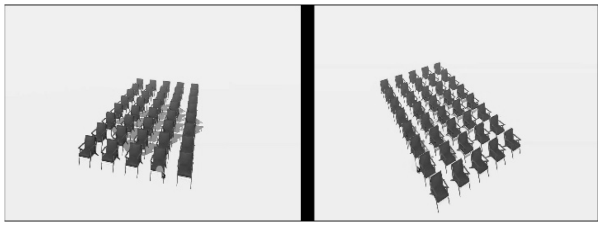

Fig. 8. 3D seat plan feature

C. Mobile App for Updating Availability

To synch the real-time information, a small mobile app was also developed that can be used by the faculty members to update the data in the system whether they are available or not. This simple app is merged with the database of the smart assistant system that can show the users of the kiosk, whether the desirable person they want to meet is available at the time or not. The mobile app was developed using NodeJS.

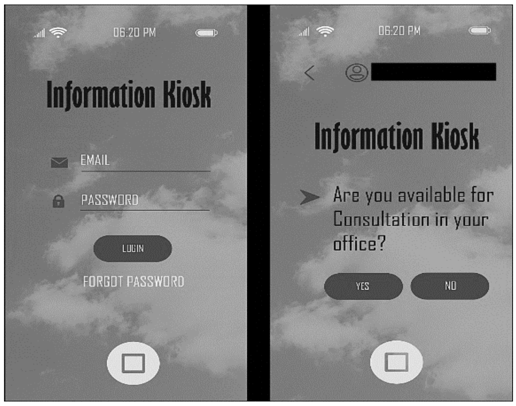

Fig. 9. Developed mobile app for updating availability status to the information kiosk

The simple mobile app can connect to the localhost database and updates the availability of the person. Only authorized persons can log in to this simple mobile app using their mail address and password as their authorized mail and password are stored in the database at the preceding period. Only admins of the system can add or remove the user accounts of this simple mobile app. Fig. 9 shows the image of the developed simple mobile app for the faculty members that show their availability on the kiosk's database. Users seeking a specific person's availability can get the information that is updated by the person through this mobile app. The left side of Fig. 9 shows the login page that leads to the availability status page as shown on the right side of Fig. 9.

D. Embedded Multiple Sensors of the System

In order to collect and provide real-time data to the users, the system was developed to have embedded multiple sensors with the device. Based on the functions of various sensors, the smart assistant system can provide users with different types of biomedical and environmental information. In this particular system, these sensors are basically connected with an Arduino Uno Microcontroller which is ultimately connected with the Raspberry Pi. The code fed into the Arduino Uno was developed and merged in such a way that it can control multiple sensors at a time. In this project, the following sensors were used: Temperature Sensor, Humidity Sensor, Pulse Sensor, and RFID Sensor.

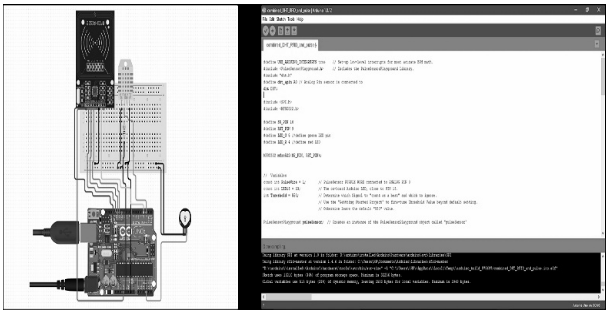

Fig. 10. Basic Circuit diagram of the sensors connected to Arduino Uno and the code written to run multiple sensors at a time

Fig. 10 shows the circuit diagram and a sample of the written code which was fed into the Arduino Uno for running multiple sensors at the same time. On the other hand, Fig. 11, Fig. 12, and Fig. 13 show the result from the output serial monitor that these combined sensors produced.

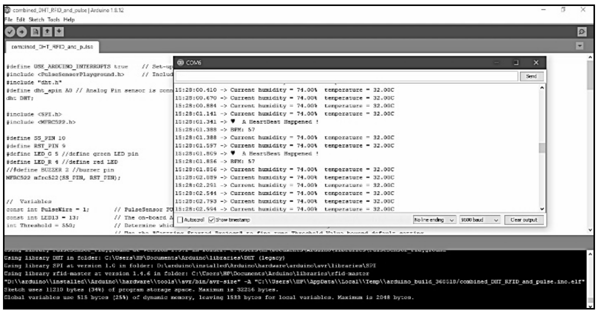

Fig. 11. Resultant data from the sensors (Temperature, Humidity, Heart Pulse) observed in the serial monitor

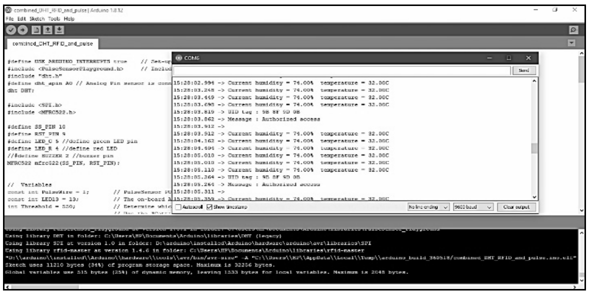

Fig. 12. Resultant data from the sensors (Temperature, Humidity, RFID – Granted Access) observed in the serial monitor

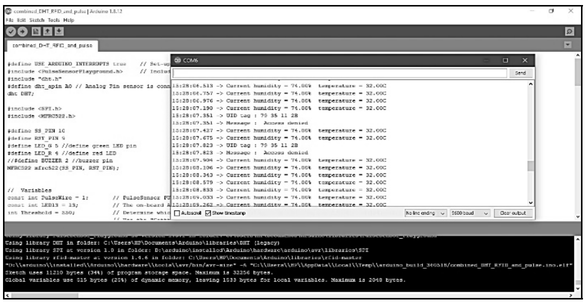

Fig. 13. Resultant data from the sensors (Temperature, Humidity, RFID – Denied Access) observed in the serial monitor

IV. Results & Discussions

The whole system was maintained in such a way that it can store the database in a localhost server or cloud server. An application program was developed for the Raspberry Pi that can access those data and also executes programs as per the user's need. For making the device more interactive, several sensors with Arduino Uno along with sound system are also connected with the Raspberry Pi. As a result, whenever the main processor, Raspberry Pi is connected with any touchscreen display and internet, the system can work quite efficiently as a 'plug & play' system. In order to test the accuracy of the device, numerous samples were taken with the camera. In every case, the image processing algorithm showed good accuracy. As shown in Fig. 14, the device can detect humans from various distances and angles.

Fig. 14. Human Detection Using Computer Vision

The results have varied according to the angle of the camera and the brightness of the captured location. Whenever the detection accuracy rate is higher than 60%, the touchscreen display of the kiosk is powered up with a welcoming sound by the sound system. One of the outcomes that this project has provided is the current consumption was kept at a minimum level. Therefore, the device is proven to waste less energy and keeping it interactive with the users at the same time as well. Fig. 15 shows the current consumption rate in different states and for performing different types of tasks.

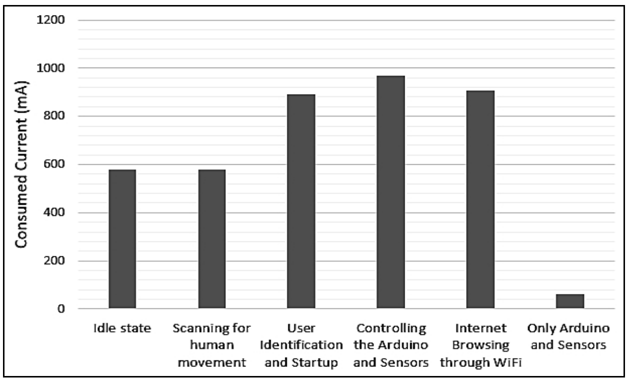

Fig. 15. The current consumption rate of various tasks & states

Fig. 15 shows that the overall current consumption is mostly below 1A. The ratings were taken practically by using a multimeter. The current consumption shown here is only by the Raspberry Pi, Arduino, and sensors. But a large portion of the current is consumed by the monitor or display section itself. But this large portion varies with different types of monitors as the system was built as a 'plug & play' system; therefore, with different types of monitor or touchscreen display, different amount of current will be consumed by the display section.

In Fig. 16, the homepage of the device can be observed. The home screen of the kiosk is completely user-friendly so that the users can feel comfortable with the device while using it. Once a user clicks on any of the options from the screen as shown in Fig. 16, the screen changes to that particular window. Fig. 17 shows a practical test run of the system. As shown on the left side of Fig. 17, the homepage screen will be lightened up on the display as it detects a human presence.

But, whenever the user is within the touching distance to operate the device, the homepage screen will automatically change to a formation as shown on the right side of Fig. 17. Thus, making the device to be more interactive and user-friendly.

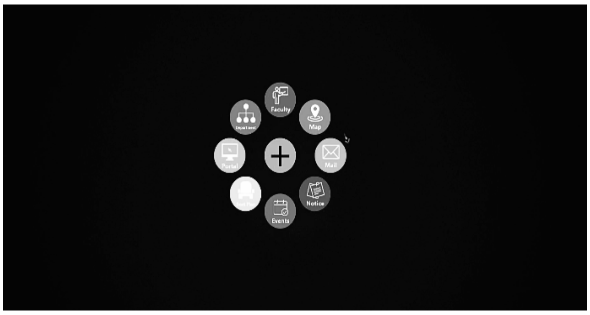

Fig. 16: Device Home Screen

Fig. 17. Practical test runs of the system

Fig. 18 shows a test run of the system in practice inside the university for its students. The users can easily navigate the system and its features. The system would also allow the users to get updated with current news and notifications about various events trending in the university. The user-friendly system enables users to easily navigate through various features of the system in order to attain the desired information.

Fig. 18. Practical test run by a user of the system

The motivation of the project was to develop a working system that will largely impact the daily activities within an organization. The goal was reached as most of the requirements were met successfully. All the desired features were tested after the project implementation and showed the desired accuracy.

V. COMPARISON WITH EXISTING KIOSKS

The available kiosks which have similarity with our model in the market would cost around $1,650 to $4,000 depending on different features [18]. The comparison based on different features and prices has been included in Table I. The traditional kiosks of higher configuration would only work as a computer with no defined feature service for a particular organization. On the other hand, the estimated cost of our developed system with the device would cost around $840 to $980 depending upon the additional features. The majority of the estimated price is based on the type of display to be used. In terms of performance, this kiosk can perform at a decent speed due to the use of Raspbian OS and, which is renowned for being a lighter OS than others. In order to reduce the heating of the Raspberry Pi, an external fan was also used, which will help to ensure similar performance in the long term. We have developed a 'plug and play' system hence any display or control system can be converted as our Developed Kiosk can work quite efficiently with any display or control system it is connected with. Therefore, an organization can modify and use the system as per their requirement without the complication of making it compatible with the display device or controllers.

TABLE I. Compact Comparison with Compatible Kiosks [18]

Parameters	Kiosk Types			
	Indoor Kiosk	Outdoor Kiosk	All-in-One Kiosk	Developed Kiosk
Computer	✔	✔	✔	✔
Touch-Screen	✔	✔	✔	✔
Webcam	✔	✔	✔	✔
Water-Sealed		✔	✔	
RFID Reader			✔	✔
Price ($)	1700	3400	4000	880

VI. CONCLUSION & FUTURE SCOPE

In this paper, we have described the function of our developed information kiosk. The kiosk uses various modern technologies including computer vision and can provide the required information in order to reduce data collection time within an organization. We implemented the device from the perspective of a university. Therefore, it can show necessary information for the students and the visitors of the institution. To ensure the security of the organization, every information is not accessible without proper verification. In this case, only the students can access their faculty's information and can mail them using the system. We have used image processing for detecting the user and the result showed that it had a success rate of 98.5% in detecting humans, 95% in detecting gender, and 40% in detecting the emotion of the user. The device also had a low current consumption which was less than 1A on average. The device was built to be interactive and user friendly in delivering the data to the user with the help of a 3D map, Multiple Sensors, interactive device apps, etc. A simple mobile app was also developed to update the availability of faculty members for their consultation. Furthermore, the system was built secured to avoid any sorts of breaching or malfunction caused by an external source. In addition to that, the device is much efficient and has more features at a lesser cost than the available kiosks in the market. For a versatile device like this one, the future scope is huge. The feature of this device can be changed according to the organizational need. We have a plan to add various healthcare features in the future in order to make this device more versatile.

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